December 2011 MSS/LPS/SPS Joint Subcommittee Meeting
ABSTRACT SUBMITTAL FORM

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ABSTRACT INFORMATION

Title: CFD Study of the J2-X LOX Two-bladed Inducer in the Presence of a Circumferential Groove

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MANAGEMENT APPROVAL

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Unclassified Abstract

(250-300 words; do not include figures or tables)

Results are presented of a computational fluid dynamics (CFD) study done in support of water flow experiments of the J-2X Oxidizer Turbopump (OTP) 2-bladed inducer with a circumferential groove that were conducted at Marshall Space Flight Center (MSFC). Sub-scale water flow testing results indicate that the circumferential groove greatly reduces synchronous cavitation and subsequent bearing loads at a minimal performance cost, but the energy reappears as high order cavitation (HOC) that spans a relatively large frequency range. Thus, HOC may have implications for the full-scale OTP inducer in terms of reduced structural margin at higher mode frequencies. Simulations using the LOCI-Stream CFD program were conducted in order to explore the root physical cause of the HOC. It was found that the axial recirculation pattern in the circumferential groove causes high-swirl fluid to interact with the nearly-axial incoming fluid just above the inducer blades. The high-shear interface between the fluids is Kelvin-Helmholtz unstable, resulting in trains of low pressure regions or 'pearls' forming near the upstream edge of the groove. When the pressure in these regions becomes low enough and they get cut by the blade leading edge, HOC is thought to occur. Although further work is required, the numerical models indicate that the root cause of HOC is hydrodynamic. That is, the pearls are always present, even when cavitation is not. Comparisons to ongoing water flow experiments will be discussed, as well as predictions for the full-scale OTP inducer.